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Sedimentology and Gold Placer Deposits-- Cathedral Bluffs Member of the Wasatch Formation, Dickie Springs-Pacific Butte Area, Fremont County, Wyoming

by

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

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ABSTRACT

The Cathedral Bluffs Member of the Wasatch Formation in the Dickie Springs-Pacific Butte area is composed of 50 to 230 m of interlayered conglomerate, sandstone, and mudstone deposited as proximal alluvial fans during uplift of the Wind River Range in early to middle Eocene time. Boulder conglomerate, consisting of poorly sorted, unoriented clasts and containing boulders as much as 8 m (long axis), is interpreted as debris flow deposits. Well-sorted, imbricated pebble-cobble conglomerate, which locally overlies boulder conglomerate, is interpreted as braided stream deposits derived partly from reworking of debris flows. The two types of congomerate occur as interstratified sheets and lenses which range in thickness from about 0.5 to 8 m. Immature arkosic sandstone probably also represents braided stream channels. Extensive, poorly exposed mudstones are interpreted as floodplain deposits.

Gold placers of low tenor were deposited by braided streams on the alluvial fans in Eocene time. Erosion of the gold-bearing Eocene conglomerate and sandstone during Quaternary time left colluvial lags on the tops of buttes and on debris-covered slopes that are enriched in gold. Both primary Eocene placers and Quaternary colluvial lags were locally concentrated into small deposits of late Quaternary alluvium.

INTRODUCTION

Boulder conglomerate in the Eocene Cathedral Bluffs Member of the Wasatch Formation in the Dickie Springs-Pacific Butte area near South Pass, Wyoming has been estimated on the basis of surface sampling to contain more than 28,500,000 ounces of placer gold (Love and others, 1978). However, the validity of this large estimate is dependent upon the uniform distribution of gold in a little-known stratigraphic sequence. Because a correlation should exist between depositional environment and gold concentration, a sedimentologic study of the area was conducted to provide more data on the depositional environment of the placers. The main objective of this paper is to identify probable gold-bearing facies of the Cathedral Bluffs Member based on sedimentologic criteria.

The study area is located at the southeast edge of the Wind River Mountains in west-central Wyoming about 65 km south of Lander and 85 km northeast of Rock Springs, Wyoming (fig. 1). The Atlantic City-South Pass gold mining district is located 25 km northeast of the study area.

Principal topographic features are two dominant buttes, Pacific Butte and Dickie Springs Butte, which lie along an east-west trending highland divide. This divide separates the Sweetwater River drainage on the north from the Great Divide Basin, an area of interior drainage encircled by the Continental Divide, on the south.

PREVIOUS STUDIES

Stratigraphic and structural relations of the Tertiary formations in the northwest part of the Great Divide Basin were studied by Nace (1939), who believed that the boulder conglomerate beds in the Cathedral Bluffs Member were deposited by Pleistocene glaciers. Zeller and Stephens mapped the Dickie Springs and Pacific Springs 1:24,000 scale quadrangles (1964a, 1964b), and described the stratigraphy, structure, and mineral resources of the Oregon Buttes area (Zeller and Stephens, 1969). They supposed the source of the placer gold to be "gold-bearing conglomerates of the lower part of the

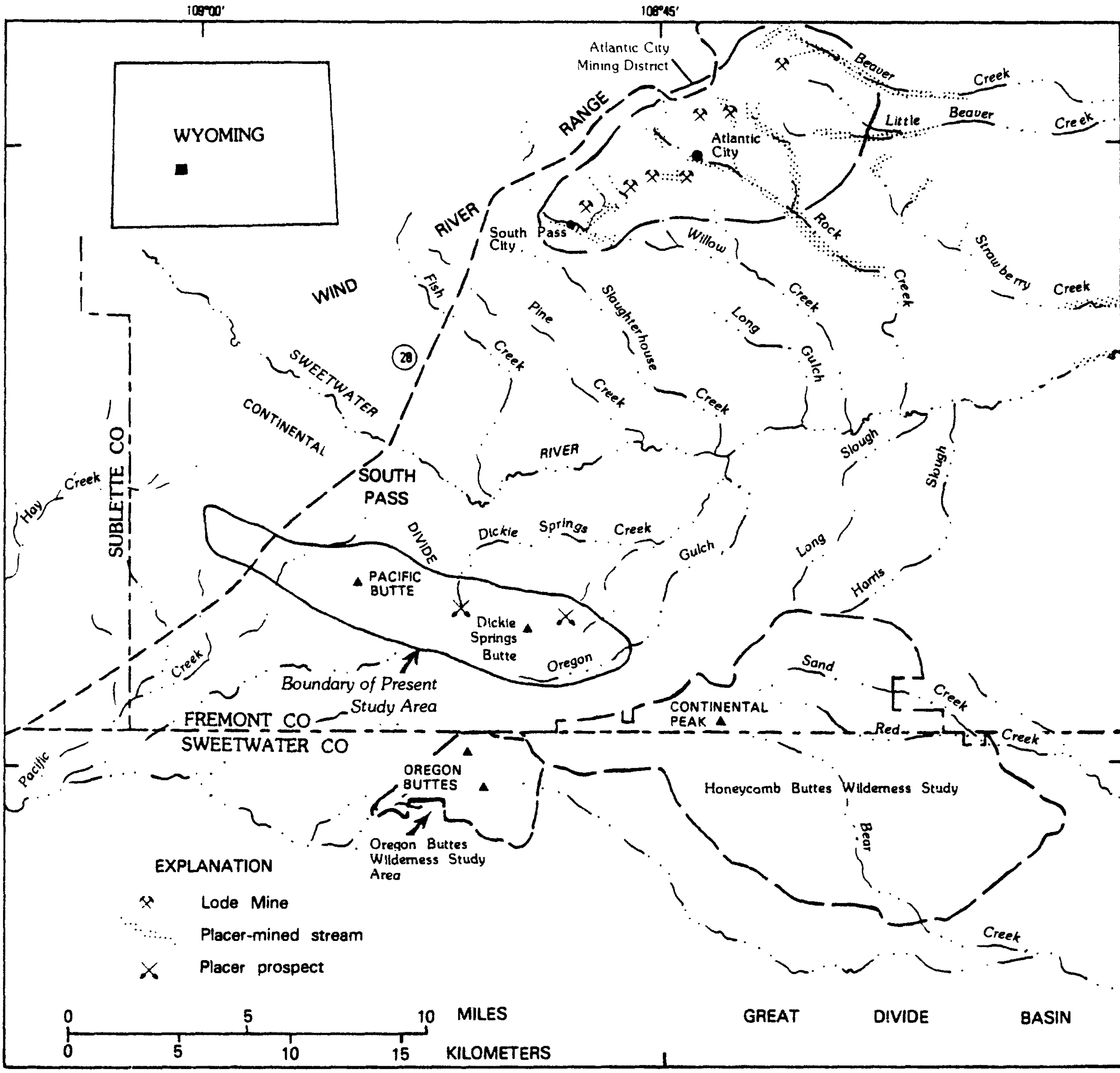

Figure 1.--Map showing location of the study area, gold lode and placer mines in the Atlantic City-South Pass mining district, and principal geographic features. Location of placer-mined streams in the Atlantic City-South Pass mining district modified from Spencer (1916).

Arikaree Formation that are exposed on the north side of the Continental Fault." Based on surface sampling over the Dickie Springs-Pacific Butte area, Love and others (1978; U.S. Geological Survey, 1979) concluded that over 28,500,000 ounces of gold may be present in the matrix of boulder conglomerates in the upper Cathedral Bluffs Member of the Wasatch Formation. They determined that the conglomerate formed a 400 m thick layer covering an area of 12.5 sq km in the Dickie Springs-Pacific Butte area. Trace element data from gold samples suggest that the lode source for the placer gold is located in granitic rocks in the headwaters of the Sweetwater River.

REGIONAL GEOLOGIC SETTING

The South Pass area lies on the boundary between Archean igneous and metamorphic rocks of the Wind River Range to the north and Eocene fluvial and lacustrine rocks of the Green River Basin to the south. The Continental fault (fig. 2), an east-west trending, recurrently active listric fault which extends for over 80 km along the southwest margin of the Wind River Range, separates these two terranes. Rocks of the Wasatch and Green River Formations intertongue in the part of the study area directly south of the Continental fault. The Cathedral Bluffs Member of the Wasatch Formation, a 50- to 230-meter-thick sequence of interlayered mudrock, sandstone, and conglomerate, is the principal unit exposed at the surface directly south of the fault, and it also appears to host the most widespread gold placers (Love and others, 1978). The Arikaree and South Pass Formations locally overlie Archean rocks to the north of the Continental fault.

In early to middle Eocene time, the Continental fault is thought to have raised Archean rocks on the north side resulting in deposition of alluvial fans, represented by the Cathedral Bluffs Member of the Wasatch Formation (McGee, 1983; Steidtmann and others, 1983). In post-early Miocene time, the fault was reactivated, but with opposite sense of displacement (Groll and Steidtmann, 1985). Rocks on the north side of the fault were downdropped about 450 m relative to those on the south.

The present landscape of the study area south of the Continental fault developed in response to weathering and differential erosion of heterogeneous rock units in the Cathedral Bluffs Member. Where resistant rock types such as well-cemented sandstone or conglomerate are present, ridges or buttes are formed. Where only nonresistant rock types (such as mudstone or poorly cemented sandstone) are present, swales or low hills are developed. Colluvial lag deposits, derived from the hillcapping conglomerates by eolian deflation and slope wash, mantle most hillslopes and obscure the underlying units. In many areas the lag deposits are unstable and have slid into adjacent valleys.

SEDIMENTOLOGY

The Cathedral Bluffs Member is typically poorly exposed and thicknesses and lateral facies relationships are obscure. Facies relationships are best exposed in an area of badlands topography along the Continental fault scarp 1 km west of South Pass (secs. 3 and 4, T. 27 N., R. 102 W.). Four main lithofacies types are identified (table 1). Descriptions of each lithofacies follows:

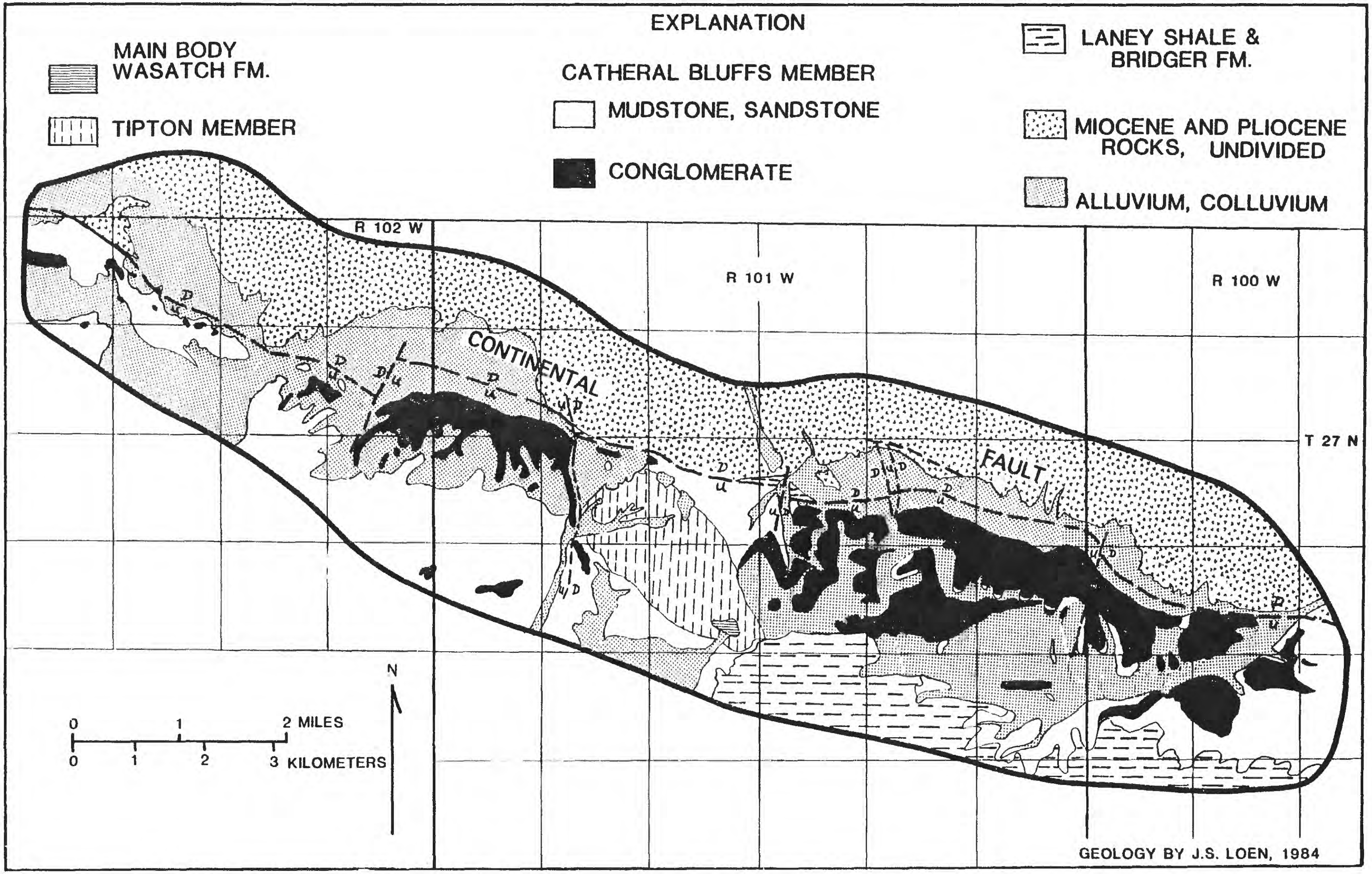

Figure 2.--Generalized geologic map of the Dickie Springs-Pacific Butte area, Fremont County, Wyoming.

Table 1.--Lithofacies of fluvial sedimentary rocks in the Cathedral Bluffs Member, study area (facies codes are based on Miall, 1977)

Rock Unit	Facies Code	Lithofacies	Interpretation
Mudstone	Fm	Clayey siltstone, silty claystone	Overbank deposits
Sandstone	St	Sand, medium to very coarse, conglomeratic	Dunes (lower flow regime) in braided stream channels
Pebble/cobble Conglomerate	Gm	Massive or crudely bedded clast-supported gravel	Longitudinal bars, lag deposits in braided stream channels
Boulder Conglomerate	Gms	Massive, matrix-supported gravel	Debris flow deposits

Lithofacies 1: (Mud and silt)--Mudstone forms the thickest and most widespread rock type in the Cathedral Bluffs Member. The mudstone typically ranges in color from pastel red, maroon, and purple to green and gray, with green and gray colors more abundant in the upper tens of meters of the section. The mudstone typically is massive, and forms badlands topography where exposed on steep escarpments. The mudstone consists of upward-fining depositional couplets of clayey siltstone and silty claystone that range in thickness from 3 cm to 1 m (Braunagel and Stanley, 1977). Mixed layer illite-smectite is the dominant clay mineral. Some beds contain tuffaceous material, and these beds preferentially form badlands topography along steep, unvegetated slopes.

Lithofacies 2: (Trough-crossbedded sandstone)--Medium- to coarse-grained conglomeratic arkosic sandstone forms a minor, but widespread part of the Cathedral Bluffs Member. The sandstone is commonly brown or yellow, arkosic, and forms cross-stratified tabular bodies up to 6 m thick. Medium-scale trough cross beds are typically abundant. Crossbeds and pebble imbrications indicate diverse current directions. Individual sandstone beds are about 3 to 10 cm thick and fine upwards. Sorting is poor. Sand grains are composed mainly of quartz, feldspar, biotite, and lithic fragments derived from Archean igneous and metamorphic rocks.

Lithofacies 3: (Massive, clast-supported gravel)--Moderately well-sorted clast-supported conglomerate contains pebbles and cobbles of Archean granite, pegmatite, gneiss, graywacke, and schist in a clean sandy matrix (fig. 3). The conglomerate is gray in color, even where completely encased by pastel mudstones of lithofacies 1. The deposits are massive and poorly consolidated. Clasts are typically subrounded to well rounded. Clast imbrication is well developed and indicates southward paleoflow. The beds thin rapidly towards the south. The geometry of a few well-exposed gravel bodies is sheetlike.

Figure 3.--Clast-supported conglomerate in Cathedral Bluffs Member. Note moderate sorting and rounding of clasts. Conglomerate, interpreted as braided stream deposit, overlies mudstone, inferred to be floodplain deposits.

Lithofacies 4: (Massive, matrix-supported gravel)--Matrix-supported boulder conglomerate consists of polymodal assemblages which typically include both large angular boulders and well-rounded pebbles and cobbles. The clasts are not imbricated (fig. 4). Clast lithologies are the same as for lithofacies 3. The conglomerate is poorly consolidated and contains poorly sorted clasts in a gritty fine-grained matrix. Boulders up to 8 m long occur locally, and boulders 0.5 m long are fairly abundant throughout the lithofacies. The largest boulders occur at the top of the exposed section directly south of the Continental fault scarp.

FACIES RELATIONSHIPS

Lithofacies 2, 3, and 4 form sheets and lenticular bodies within lithofacies 1 (fig. 5). Where present, conglomerate beds generally consist of interstratified beds of lithofacies 3 and 4 (fig. 6). The interstratified conglomerates are typically 0.5 to 8 m thick. In many exposures lithofacies 3 overlies lithofacies 4. This relationship, along with the similar clast composition of the two conglomerates and the better rounding and sorting of lithofacies 3, suggests that lithofacies 3 is, in part, derived from lithofacies 4 by fluvial reworking. Lithofacies 2 typically occurs independently of the conglomerate units.

On Dickie Springs Butte and Pacific Butte the rocks are covered with thick colluvial lags but the same relationships apparently are present as in the well-exposed northwest part of the study area. The buttes display stepped profiles consisting of ledges underlain by conglomerate and sandstone separated by gentle slopes underlain by mudstone.

INTERPRETATION OF DEPOSITIONAL ENVIRONMENT

Previous studies have established that the Cathedral Bluffs Member represents alluvial fans that prograded southward from the Wind River Range during its uplift in Eocene time. The four lithofacies described in this report were part of these alluvial fans. The depositional environments on the fans were partly controlled by the climate, which was probably subhumid subtropical (Leopold and MacGinitie, 1972; Childers, 1974). Studies in other areas suggest that the main depositional processes on alluvial fans in humid regions occur by braided stream and debris flow (Kochel and Johnson, 1984, p. 120).

Mudstone (lithofacies 1) represents floodplain facies of alluvial plains (Braunagel and Stanley, 1977; Sullivan, 1980; McGee, 1983; Steidtman and others, 1983). Mud, silt, and clay were deposited from the suspended load of overbank floodwater during low-energy conditions. The predominance of mudstone in the study area suggests that extensive mud flats existed adjacent to the Wind River Range during Eocene time.

Arkosic sandstone (lithofacies 2) may represent alluvium of braided stream channels deposited on the broad mud flats by small streams draining south from the Wind River Range. The stream systems were aggrading in response to the uplift of the range.

Clast-supported cobble conglomerate (lithofacies 3) is also interpreted as braided stream deposits. The conglomerate had a more proximal source than the sandstones, however. The streams that deposited the conglomerate also had much greater competence than the streams that deposited the sandstones. The conglomerates may thus represent proximal trunk channels, and the sandstones distal distributaries on the surfaces of the alluvial fans. Periodic debris flows into the trunk channels from mountain slopes to the north may have provided a discontinuous supply of coarse gravel that was reworked by streamflow.

Figure 4.--Matrix-supported conglomerate in Cathedral Bluffs Member. Note unsorted nature of deposit. Matrix consists of fine-grained sand, silt, and clay. Interpreted as debris flow deposit.

Figure 5.--Lenticular conglomerate beds in Cathedral Bluffs Member. The conglomerate lenses range in thickness from about 0.5 m to 3.0 m and thin southward. Butte is capp with residual gravels derived from conglomerate lenses. Coarsest boulders occur at top of exposed sequence (n boulders up to 1.5 m in diameter on ridge).

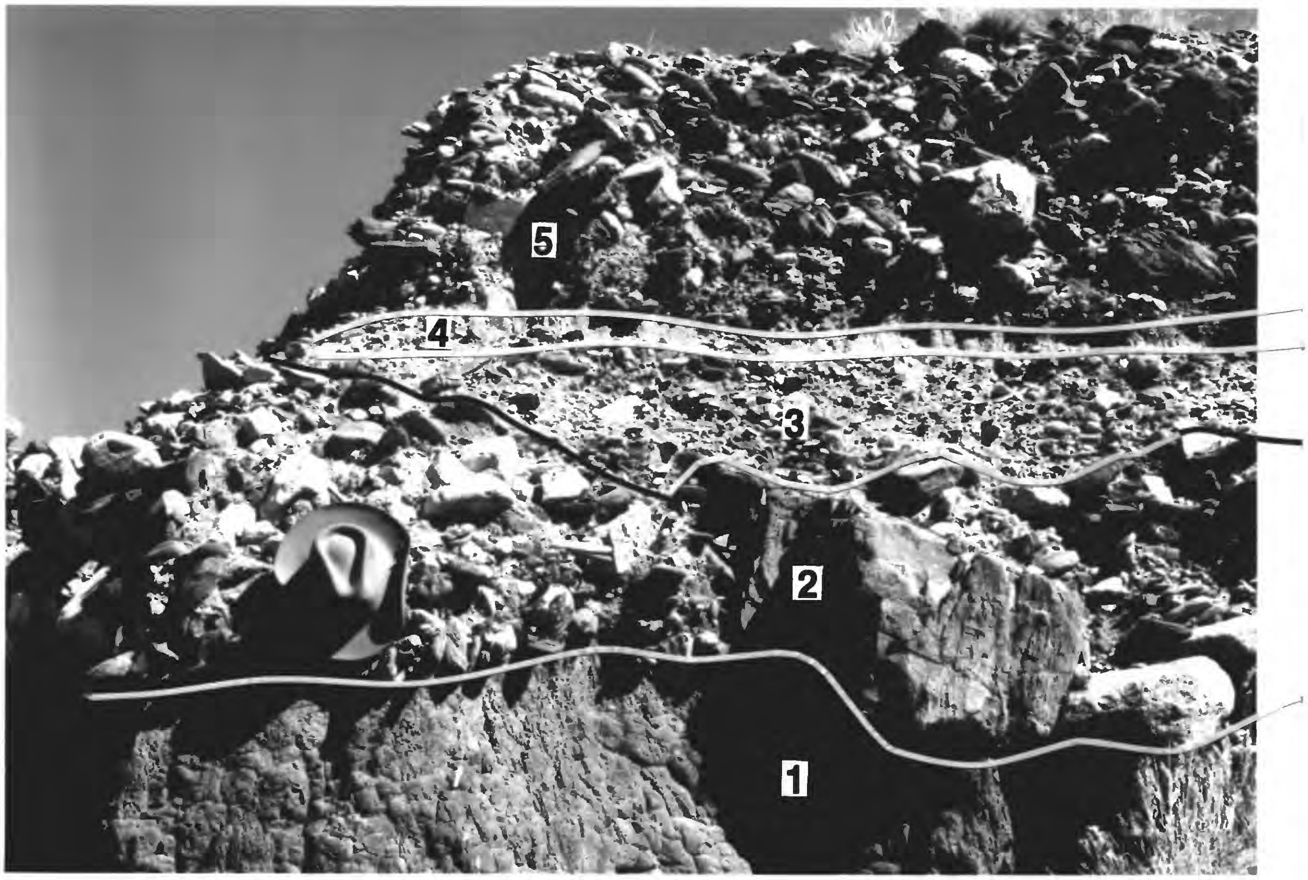

Figure 6.--Clast- and matrix-supported conglomerate interlayered with mudstone in Cathedral Bluffs Member. Units shown are: (1) mudstone (floodplain deposits), (2) poorly sorted boulder conglomerate (debris flow), (3) well-sorted pebble/cobble conglomerate (braided stream deposits), (4) mudstone (floodplain deposits), and (5) imbricated pebble/cobble conglomerate (braided stream deposit). Note irregular scour surface between braided stream deposit (3) and underlying debris flow (2). Photo by K. E. Cohan, August 1985.

Matrix-supported boulder/cobble conglomerate (lithofacies 4) is interpreted as debris flows. This interpretation is consistent with the poorly sorted, chaotic texture of the conglomerate and the local presence of boulders as much as 8 m (long axis). The process of mass flow associated with debris flows also represents the only reasonable way to transport boulders from a central mountain range and deposit them radially along a surrounding piedmont.

The occurrence of coarse conglomerate between thick intervals of floodplain mudrocks suggests that gravel deposition may have occurred episodically. Coarse gravels may have been deposited only following periods of uplift. Debris flows, probably triggered by earthquakes or floods, supplied gravelly debris that was gradually reworked by streams in trunk channels. Conglomerates may thus represent unconformities that developed in response to episodic sedimentation cycles. These unconformities may represent favorable horizons for placer formation because of extensive reworking.

PLACER GOLD DEPOSITS

Placer gold was prospected during the late 1800's in Quaternary alluvium in two areas located north and west of Dickie Springs Butte, respectively (fig. 1). If any gold was recovered it must have been small considering the scarcity of water, the small total size of the workings, and conflicts with Indians during mining. Some miners reportedly made wages by hauling the gravel 7 km to water (Love and others, 1978, p. 379). Prospecting also was done in this area during the 1930's and in 1976. No production was reported in Minerals Yearbook (published annually by the U.S. Bureau of Mines) for these years, however.

TYPES OF PLACERS

The placers are of at least four types, (1) Eocene channel conglomerate and sandstone of the Cathedral Bluffs Member; (2) sandstone of the Arikaree Formation; (3) Quaternary colluvium; and (4) Quaternary alluvium. The younger types of placers represent concentrations of the older types by reworking. Only Quaternary alluvium has been mined in the study area.

The primary placers are probably Eocene channel sandstones and conglomerate (corresponding to lithofacies 2 and 3). The grade of the Eocene placers has not been reliably estimated, but the deposits represent the largest volume of potentially gold-bearing rock in the area (numerous conglomerate layers 0.5 to 8 m thick are present in an area of approximately 10 sq km). Younger Tertiary sedimentary rocks also contain placer gold (Zeller and Stephens, 1969, p. 38; Love and others, 1978, p. 388). Colluvial lag deposits consisting of unsorted gravel sheets on the tops and sides of buttes represent effective concentrates of Eocene conglomerate. During the accumulation of the lag gravels, light and non-resistant minerals were removed by eolian deflation, weathering, and rain wash, and heavy, resistant minerals (including gold) were concentrated. Alluvium represents a further concentrate of the colluvial placers by winnowing during fluvial transport. Quaternary alluvium contains the highest known concentations of gold (up to 0.0791 oz/cu yd, n=27, mean=0.0105 oz/cu yd, std. dev.= 0.0189; Love and others, 1978).

DISCUSSION

Boulder conglomerate (lithofacies 4), identified as the host rock of placers by Love and others (1978), was probably deposited by debris flows. Processes of mass flow which operate during deposition of debris flows are unfavorable for the concentration of heavy minerals; however, conglomerate and sandstone have been recognized as host rocks of placer gold on alluvial fans of many ages throughout the world (Smith and Minter, 1980; Pretorius, 1981). I suggest that more likely hosts of the Eocene placers in the study area are deposits of braided streams, not debris flows. Braided stream deposits that probably contain placer gold include the arkosic sandstone (lithofacies 2), and pebble/cobble conglomerate (lithofacies 3).

Studies in other areas also indicate that Eocene conglomerate and sandstone contain gold placers. At Iron Springs Divide, Moffat County, Colo. (25 km NW of Craig, Colo.), over $200,000 in placer gold (about 10,000 oz at $20.67/oz) was mined from sandstone in the Cathedral Bluffs Member and in the Tipton Tongue of the Green River Formation, and from alluvium derived from these sandstones (U.S. Geological Survey, 1970; Parker, 1974). The topography and geology in the Iron Springs Divide area is similar to the study area. Resistant sandstone and conglomerate underlie prominent buttes. Placer deposits consist of Eocene conglomeratic sandstone, Quaternary alluvium in terrace gravels and stream gravels, and sandy surface mantle. Underground mines have been driven along channels in poorly consolidated conglomeratic sandstone. Theobald (U.S. Geological Survey, 1970, p. A6) determined that "placer deposits flanking Iron Springs Divide, Moffat County, Colorado, have a local source in arkose lenses of an Eocene deltaic fan." Sedimentologic evidence, experimental studies, and work in similar areas thus suggest that boulder conglomerate in the study area cannot be viewed as a viable placer gold resource.

The richest placer deposits that occur in alluvial fan settings are quartz-pebble conglomerate characterized by their high textural maturity. Proterozoic placers in the Witwatersrand of South Africa, for example, are composed of coarse-grained quartz arenites and oligomictic conglomerates whose maturity is indicative of extensive reworking during deposition (Minter, 1978, p. 824). Conglomerates and sandstone in the study area, however, are distinctly polymictic and immature, reflecting a lack of effective reworking during transport and deposition. Therefore, placers that may be present are probably of relatively low grade.

Indiscriminate surface sampling of bouldery colluvial lag deposits in the study area may incorrectly suggest high gold content of the underlying boulder conglomerate in the Cathedral Bluffs Member. Pan samples of surface mantle from the Iron Springs Divide area typically show a few colors (Parker, 1974), indicating perhaps that some surficial gold concentration also occurred in that area during the Quaternary erosion that produced the colluvium. Placer gold sampling by Love and others (1978, p. 385) was performed generally "just below grass or sagebrush roots." Their results may reflect, in part, surficial concentrations of gold. This process is acknowleged by them (p. 385): "... the highest concentrations of gold occurred in gravel veneer derived from the Wasatch and deposited north of the Continental fault on rocks of Miocene age." In future sampling programs, therefore, subsurface units should be tested rather than colluvium because, although the colluvium may have a relatively high gold content, it is normally too thin to be mined commercially.

CONCLUSION

The sedimentological character of rocks in the Dickie Springs-Pacific Butte area suggest that a much smaller amount of placer gold may be present than was previously estimated. Primary gold placers probably occur in moderately well-sorted pebble/cobble conglomerate and sandstone deposited by braided streams rather than in boulder conglomerates deposited by debris flows. Rather than one 400 m thick layer of gold-bearing conglomerate covering an area of 12.5 sq km (Love and others, 1978), the Cathedral Bluffs Member in the Dickie Springs-Pacific Butte area consists of numerous thin (0.5 to 8 m thick) layers of interlayered clast- and matrix-supported conglomerates and sandstones over an area of about 10 sq km. Only the well-sorted clast-supported conglomerate beds and sandstones in these layers appear favorable for the occurrence of placers.

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